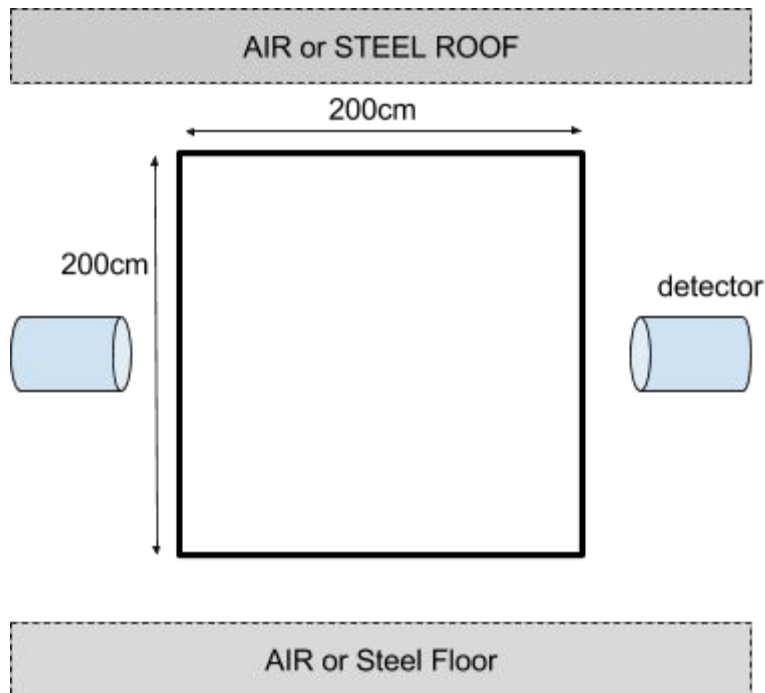


# Qualifying Exam, 2016

## ADNS and NTMP

You are a nuclear smuggler of international fame. You want to smuggle 6kg of Weapons Grade Plutonium (WGP) into the US. However, you know that the gates into the United States of America are guarded by *Aregjan the Fearsome*. He scans every container with his (precious) array of (**fast**) neutron detectors. His detection algorithm is exceedingly simple (he is not that fearsome after all) -- detecting neutron counts *larger* than the cosmic neutron background by  $2\sigma$  will raise an alarm.

- what is Aregjan's system's false positive (false alarm) rate (assuming normally distributed fluctuations in the background)?
- you can choose between different material types to shield the neutron emission from the Pu. Suggest the optimal configuration. On the diagram below, suggest the optimal positioning of the Pu. What if the floor and the "roof" of the system are made of thick steel plates?



- Let's say you fill your container with your shielding of choice. Let's say the 6kg Pu object is at the center, and the mean free path for neutrons in this material is 10cm. Assume

that any interaction will result in the “loss” of the neutron (from the detector’s energy acceptance, anyway). Determine the neutron rate from Pu (~50kHz/kg of neutrons emitted into  $4\pi$ ) in a detector array with the total solid angle of 0.13 steradians and intrinsic efficiency of 50%. The committee members will help with the arithmetics.

- d) the *mean* background cosmic neutron rate in that detector array is 1Hz -- this number is well known to Aregjan due to previous measurements. Given the above threshold, how long does Aregjan have to measure to achieve a 97% detection probability for this particular scenario?
- e) Aregjan has done the same calculation and is not happy with the answer, and wants to achieve this faster -- suggest a few technical solution, using:
  - i) same configuration, but additional detector types
  - ii) reconfiguring (think shielding)
  - iii) same neutron detectors and general configuration, but additional (expensive) equipment, different physics processes...
- f) Aregjan has an intelligence service, lead by his doppelganger -- *Scottrick the Ironhand*. Scottrick has advised Aregjan that a nuclear smuggling operation is imminent, and has estimated the probability of an attempt on a particular day at 90%. Propose a Bayesian calculation to determine the probability that, given the scenario with the counts registered above, a smuggling attempt is underway.